OIL FIRES IN OKLAHOMA AND TEXAS

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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OIL FIRES
IN
OKLAHOMA AND TEXAS

A THESIS

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to the

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OIL FIRES IN OKLAHOMA AND TEXAS

INTRODUCTION.

The protection of life and property against loss by fire is of vital economic importance. To those concerned with the production of petroleum many of the problems presented by the fire hazard are as yet unsolved. The investigation here described was undertaken, by the writer, for the Department of the Interior, Bureau of Mines, Petroleum Division, in order to obtain information relative to past oil fires and present prevailing conditions, with the idea of offering precautionary suggestions for the benefit of oil producers and other interested persons.

According to authentic records the first oil well, drilled by steam power, in the United States was drilled near Titusville, Pa. in August 1859 by Mr. E. L. Drake. Thus the year 1859 marks the beginning of the commer-

cial development of oil resources in this country. The first flowing well was completed about two years later, and during the same year (1861) the first oil fire in this country appears on record. A flowing well near Rouseville, Pa. became ignited by the gas from the well coming in contact with the fire under a boiler at an adjacent drilling well. In the resulting fire about twenty men were killed and a like number were maimed for life.

As the number of wells drilled and the production of oil increased fires became more numerous. Perhaps the most disastrous oil fire occurred at Titusville, and Oil City, Pa. in June 1892, when upwards of one hundred lives were lost. During the last few years the marked increase in the production of oil has been accompanied by a decided increase in the amount of attention paid to the reduction of hazard to life and property.

HISTORY OF OIL FIRES IN OKLAHOMA AND TEXAS.

Until 1904 the oil resources of the Indian and Oklahoma territories, since 1907 the State of Oklahoma, remained practically untouched. The field as a whole began to develop with great rapidity after 1904 and in 1910 the production in Oklahoma was about 52,000,000 bbl. The first development of the petroleum industry in Texas was in the sixties. The production in that state in 1905 reached approximately 28,000,000 bbl. and decreased to 9,000,000 bbl. in 1910.

A complete record of the oil fires in Oklahoma and Texas, since the start of production there, is apparently unobtainable. An examination of all available records covering the period from January 1, 1907 to January 1, 1915 indicates the most important oil fires, in the above mentioned states, during this period as follows:

1907.

June 22nd.- Lightning, at Glenn Field, Okla., caused the loss of one 37,500-bbl. steel tank, four 1600-bbl. wood tanks, and one drilling rig.

June 26th.- At Glenn Field, Okla., Beacon Wells were ignited from a settling tank which was struck by lightning.

July 8th.- At Gladys, Texas, lightning caused the loss of 65,000-bbl. of oil in earthen storage.

July 27th.- Lightning, at Ramona, I.T., caused the loss of one 37,500-bbl. steel tank containing Glenn crude oil.

August 13th.- One 55,000-bbl. steel tank filled with Glenn oil was destroyed by a fire due to lightning at Gladys, Texas.

October 2nd.- Lightning struck in the Glenn field, causing the loss of six 1600-bbl. wood tanks and 6,000 bbl. of oil.

October 2nd.- Lightning caused a fire resulting in the loss of one 35,000-bbl. steel tank at Ramona, I.T.

October 26th.- Lightning in the Glenn field caused the loss of four 1600-bbl., one 500-bbl. and two 250-bbl. wood tanks. The 1600-bbl. tanks were several hundred feet from the others, yet all were ignited by a single flash of lightning.

1908.

February 14th.- Lightning caused a fire resulting in the loss of two earthen reservoirs, five 1600-bbl. wood tanks, and 58,000 bbl. of oil. This fire was in the Glenn field and it might also be noted that the oil lost was fresh.

March 9th.- A flowing well in the Glenn field caught fire from the sand reel becoming overheated by friction.

April 14th.- Lightning caused the loss of one 55,000-bbl. steel tank and 38,000 bbl. of crude naphtha at Beaumont, Texas.

April 21st.- Lightning, in the Glenn field of Oklahoma, caused the loss of one 55,000 and one 37,500-bbl. steel tank,

twenty-three 1600-bbl. wood tanks, and three 250-bbl. wood tanks. Most of the tanks were full of oil. One pumping rig and two ponds of oil were also lost.

May 18th.- Lightning in the Glenn field caused a fire resulting in the loss of one 55,000-bbl. steel tank filled with fresh oil.

May 28th and 29th.- Eighteen 1600-bbl. wood tanks and two drilling rigs were destroyed by fire, in the Glenn field, due to lightning.

June 25th.- A fire at Nederland, Texas, resulted in the loss of one 55,000-bbl. steel tank and contents. Lightning caused the fire.

June 29th.- Lightning caused the loss of two 55,000-bbl. steel tanks at Sour Lake, Texas. These tanks had just been filled with Oklahoma oil from the Glenn field.

July 2nd.- Lightning caused the loss of 8,000 bbl. of crude naphtha at a refinery near Port Arthur, Texas.

July 12th.- Lightning in the Glenn field, Okla., caused a fire resulting in the loss of six 1600-bbl. wood tanks and one 35,000-bbl. steel tank.

July 21st.- Refineries at Port Neches and Port Arthur, Texas, lost one 55,000-bbl., one 37,500-bbl. and one 35,000-bbl. steel tank in fires due to lightning. Two 10,000-bbl. tanks were also destroyed in these fires.

July 26th.- Lightning caused the loss of one 10,000-bbl. tank and one 2,000-bbl. tank at a refinery near Port Arthur, Texas.

August 13th.- Lightning caused a fire at Ramona, I.T., resulting in the loss of one 35,000-bbl. steel tank and contents.

August 16th.- Lightning caused the loss of one 55,000-bbl. steel tank at Port Arthur, Texas.

1909.

March 2nd.- A prairie fire from a boiler north of Tulsa, Okla., caused the loss of seven 1600-bbl. wood tanks and four 500-bbl.

wood tanks. Five wells were also ignited.

May 23rd.- Lightning caused a fire near Tulsa, Okla., resulting in the loss of five 1600-bbl. wood tanks and three drilling rigs.

June 15th.- An oil well near Madill, Okla., became ignited from a fire under a boiler at an adjacent drilling well.

July 13th.- Two 1600-bbl. wood tanks were lost in a fire at Bald Hill, Okla. No cause reported.

July 14th.- Three 1600-bbl. wood tanks were destroyed, near Tulsa, Okla., in a fire due to lightning.

July 16th.- Lightning caused the loss of one 35,000-bbl. steel tank at Osage, Okla., and one 55,000-bbl. steel tank in the Glenn field, Okla.

August 11th.- Lightning, at Port Arthur, Texas, caused a fire resulting in the loss of one 55,000-bbl. steel tank and one 37,500-bbl. steel tank. The former was half-full of oil.

August 27th.- Lightning in the Glenn field, Okla., caused the loss of five 1600-bbl., one 500-bbl., five 250-bbl. and one 170-bbl. wood tanks. Five drilling rigs were also destroyed.

September 27th.- Lightning, at Nowata, Okla., caused the loss of two wood tanks, one 1600-bbl. and one 500-bbl.

October 25th.- A grass fire near West Tulsa, Okla., caused the loss of one 37,500-bbl. steel tank.

October 31st.- Near Morris, Okla., four 1600-bbl. wood tanks and 4000 bbl. of oil were destroyed by fire due to lightning.

November 8th.- Eight 37,500-bbl. steel tanks were ignited by one flash of lightning at Beaumont, Texas, and 275,000 bbl. of oil were lost. The fire spread to another tank of the same size as the others.

November 8th. Lightning caused the loss of one 55,000-bbl. steel tank at Port Arthur, Texas.

1910.

March 19th.- Lightning caused a fire at Nowata, Okla., which resulted in the loss of the following wood tanks: two 2,000-bbl., seven 1600-bbl., four 500 bbl. and eleven 250-bbl.

March 28th.- A lighted match caused the loss of nine 1600-bbl. wood tanks, eleven 250-bbl. wood tanks and nine rigs, in the Glenn field, Okla.

April 13th.- Lightning at Bald Hill, Okla., caused the loss of five 1600-bbl. wood stock tanks.

April 13th.- Fire, due to lightning, destroyed two 1600-bbl. wood tanks at Haskell, Okla.

June 25th.- Lightning, at Port Arthur, Texas, ignited nine tanks as follows: one 55,000-bbl. steel, one 37,500-bbl. steel and seven 2,000-bbl. wood. The large tank and three of the 2,000-bbl. tanks were extinguished. About 35,000 bbl. of distillate burned.

June 25th.- One 55,000-bbl. steel tank full of Oklahoma oil was destroyed in a

fire, at Port Arthur, Texas, due to lightning

August 10th.- The fire losses, at Glenn Pool, Okla., due to lightning, were as follows: one 37,500-bbl. steel tank full of oil, one 2,000-bbl. wood tank containing distillate, three 1600-bbl. tanks and four 250-bbl. wood tanks.

August 10th.- Lightning at Delware, Okla., caused the loss of the following wood tanks: one 2,000-bbl., one 1600-bbl. and four 500-bbl.

August 16th.- One 37,500-bbl. steel tank and 4,000 bbl. of oil were destroyed in a fire, due to lightning, at El Vista, Texas.

August 21st.- Lightning caused a fire at Grayson, Okla., in which one 7500-bbl. work tank and 1400 bbl. of oil were lost.

1911.

May 20th.- Lightning caused a fire, at Lufkin Station, Texas, resulting in the loss of one 37,500-bbl. steel tank.

May 29th.- A submerged tank at a refinery near Muskogee, Okla., was struck by lightning.

June 19th.- Lightning caused the loss of one 10,000-bbl. steel tank at Sour Lake, Texas.

June 22nd.- One 35,000-bbl. steel tank, at Sour Lake, Texas, was destroyed in a fire caused by lightning.

July 6th.- Lightning caused a fire, resulting in the loss of two 1600-bbl. wood tanks at Nowata, Okla.

October 1st.- Three rigs over wells, one pump station and two 1200-bbl. wood tanks were destroyed by fire due to lightning at Sour Lake, Texas.

1913.

April 25th.- Lightning caused a fire at a refinery near Vinita, Okla., resulting in a loss of $50,000.00.

April 25th.- Twelve tanks were destroyed in a fire due to lightning striking a

refinery at Chelsea, Okla.

May 10th.- Lightning at Sour Lake, Texas, caused the loss of one 55,000-bbl. steel tank and one 35,000-bbl. steel tank.

June 2nd.- One 55,000-bbl. steel tank was lost in a fire, at Sour Lake, Texas, caused by lightning.

August 5th.- Lightning caused a fire at Electra, Texas, which resulted in the loss of one 55,000-bbl. steel tank.

September 21st.- Lightning caused the loss of tank near El Vista, Texas. This was the seventh tank on the same farm lost by fire due to lightning since May, 1912.

1913.

May 1st.- A barrel house at a refinery near Port Arthur, Texas, was destroyed by fire, supposed to have originated from defective wiring. Loss, $100,000.00.

May 8th.- Lightning in the Cushing field of Oklahoma caused fires resulting in the loss of four 1600-bbl. wood tanks, one

500-bbl. wood tank and one rig.

May 15th.- Four 1600-bbl. wood tanks were destroyed at Cushing, Okla., in a fire caused by lightning.

May 15th.- Lightning caused a fire, near Tulsa, Okla., in which two 1600-bbl. and three 250-bbl. wood tanks were destroyed.

May 22nd.- A loss of $50,000.00 was reported in a fire at Bartlesville, Okla. Fifteen tanks were fired by lightning and burned. One company alone lost eight.

June 22nd.- Oil tanks were struck by lightning and set on fire at a refinery near Vinita, Okla. The loss was about $6,000.00.

July 3rd.- A loss of $10,000.00 is reported due to an oil fire at Beaumont, Texas. No cause for the fire is noted.

July 11th.- One man was killed near Cushing, Okla., when an oil well became ignited from an open flame.

July 26th.- Lightning caused the loss of one 55,000-bbl. steel tank full of oil, at a refinery near Sand Springs, Okla.

August 10th.- Lightning fired two tanks near Houston, Texas, and caused a loss of $60,000.00.

August 29th.- A loss of $150,000. was reported, resulting from a fire caused by lightning in Texas.

August 30th.- Lightning caused the loss of one 55,000-bbl. steel tank near Humble, Texas. Total loss $35,000.00.

August - - - A 55,000-bbl. tank of distillate was destroyed by fire, at Nederland, Texas, due to lightning.

August - - - Lightning caused a fire resulting in the loss of two 55,000-bbl. steel tanks and 60,000 bbl. of oil at Nederland, Texas.

September 6th.- A fire, at Port Arthur, Texas, resulting in the loss of two lives and $200,000.00, was caused by lightning.

September 9th.- The loss of a 10,000-bbl. tank and a small amount of oil is recorded due to a fire, at Texas City, Texas, caused by lightning.

September 11th.- Fire resulted in a loss of $50,000.00 at Beaumont, Texas. Cause unknown.

October 7th.- Lightning caused a fire, resulting in the loss of one 35,000-bbl. steel tank and 32,000 bbl. of oil, near Tulsa, Okla.

October 7th.- A number of wood tanks were destroyed by fire, in the Cushing field, due to lightning.

October 16th.- A 7,000-bbl. tank of gasoline, at Beaumont, Texas, exploded. Loss, $10,000.00.

1914.

April 7th.- Lightning ignited a 7,000-bbl. tank of gasoline near Okmulgee, Okla. Loss $40,000.00.

April 17th.- One 55,000-bbl. steel tank was destroyed by fire caused by lightning at Sand Springs, Okla. Nearly every district in the northeastern part of Oklahoma suffered some fire loss.

May 11th.- Lightning caused a fire resulting in the loss of one 55,000-bbl. steel tank at Sand Springs, Okla. The loss was estimated at about $60,000.00.

May 28th.- Two lives were lost in the Cushing field, Okla., due to an explosion resulting from gas coming in contact with lighted headlights on an automobile.

May - - - Heavy rain in the Healdton field, Okla., caused a washout of part of the bank of an earthen storage tank. The oil ran down the river, caught fire and did considerable damage.

July 9th.- An oil tank fire at Alluwe, Okla., resulted in a loss of about $40,000.00. No cause given.

July 9th.- Lightning caused the loss of one 37,500-bbl. steel tank at El Vista, Texas.

El Vista, where a certain company has its tank farm, seems to hold a peculiar attraction for lightning. The company has lost eighteen large tanks in the last twelve months, but five of the original twenty-three remaining.

July 9th.- Lightning at Nederland, Texas, caused the loss of one 55,000-bbl. steel tank and contents. Total loss $120,000.00.

July 17th.- Lightning caused a fire at Mounds, Okla., resulting in the loss of two 55,000-bbl. steel tanks and 100,000-bbl. of oil. The first tank was struck by lightning and the second tank was ignited by the boiling over of the first.

August 27th to September 2nd.- Disastrous fires occurred in the Cushing and Healdton fields in Oklahoma. In both of these fields in Oklahoma many wells were drilled without excluding the gas, and this gas mingled with the flowing oil and escaping from the flow tanks furnished an envelope of highly flammable atmosphere over large areas. A series of electrical storms caused fires resulting in the following losses:

			Bbl. of Oil
13	55,000-bbl. steel tanks containing		600,000
50	1600-bbl. wood "	"	68,000
1	800-bbl. wood flow tank	"	5,000
3	500-bbl. " " tanks		
16	250-bbl. " " "		
2	Earthen storage tanks,	"	50,000
12	Wells,	"	2,000
	Total oil lost by fire -		725,000

A valuation on the loss, based on current prices, was approximately $706,000.00. It might also be noted that the Cushing and Healdton fields are nearly two hundred miles apart.

At Cushing, gas burned over the top of a 55,000-bbl. tank that was struck by lightning for almost forty minutes before the oil became ignited. Another 55,000-bbl. tank burned for fourteen hours before boiling over. When the burning oil was ejected from the tank it flowed to another tank and the latter was ignited and burned around the edge of the roof

for seven hours before the roof fell in and the oil started to burn. That the flames were held in check so long was probably due to the fact that live steam was maintained in this tank and it served as a blanket to prevent the air coming in contact with the gas in sufficient quantity to support combustion, except at the edge of the roof, where the amount of steam and gas was relatively small in comparison to the volume of air available. The flames were confined to the small crevice between the sides of the tank and the roof and extended about one-fourth of the way around the tank. Had the roof been tightly connected to the shell all around the tank, there is a probability that the tank would not have been destroyed.

The work of controlling the fires in the Cushing and Healdton fields was practically limited to forcing live steam into the tanks not burning and building earthen dikes to retain the burning oil, as it overflowed from the tanks, and prevent it from reaching other flammable material.

November 6th.- Fire caused by lightning destroyed a tank of oil, a loading rack and a pumping station at Bristow, Okla. At the time of the lightning stroke oil was being pumped into the tank from Drumright, Okla. In the absence of a means of communication with the source of the oil supply, for the purpose of shutting off the flow, an improvised device was resorted to for turning the oil into a refinery tank, which enabled the fire to be brought under control.

From the history as recorded above, a tabulation of the oil tank fires in Oklahoma and Texas during the eight year period from January, 1907, to January, 1915, has been made and included herewith.

Size of T
55000
37500
35000
20000
10000
7500
2000
1600
1200
800
500
250
170
Earthen Ta
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OIL TANK FIRES IN OKLAHOMA AND TEXAS

1907 - 1915

Size of Tank	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
55000 bbl.				3	3	6	6	20	4		1		43
37500				1	2	2	4	6	1	1	9		26
35000					1	1	4	1		2			9
20000									1				1
10000						1	5		1				7
7500				1					1				2
2000			2			7	1	2					12
1600		5	23	30	33	4	13	39	21	14			182
1200					4					2			6
800							2	1					3
500			8		1			7	2	1			19
250			22	3	3			19	6				53
170								1		2			3
Earthen Tank bbls.		58000		20000			65000	135000		6000			284000
Size not Listed				12	15			2					29
Loss not Listed $				90000	150000	6000	175000	350000	228000				$999000
Loss of Oil bbls.		65000	102000	231000	268000	395000	568000	1083000	229000	105000	330000		3376000

Loss Not Listed Above.	This item is distinct from items otherwise listed and include such losses as only listed in money values not indicating number or size of tanks.
Loss of Oil.	This does not include 29 tanks not listed in size.

All of the above fires were caused by lightning except 31 tanks in March containing 30,000 bbls. of oil, and one tank in October containing 20,000 bbls. of oil.

It will be noted from the tabulation that approximately 32 per cent of the total losses by fire occurred during the month of August and that there were no records of any fires during the months of December and January. About 99 per cent of all the fires were caused by lightning.

PRESENT CONDITIONS IN THE OKLAHOMA FIELDS.

GENERAL PLAN OF INVESTIGATION.

In the investigation of the present prevailing conditions it was deemed advisable to make a study of the general nature and characteristics of the material produced, the general conditions in the oil fields and on the tank farms, the causes of oil fires and the usual precautions taken to prevent and reduce fires.

NATURE AND CHARACTERISTICS OF MATERIAL.

The origin of petroleum has been the subject of much discussion among chemists and geologists for a number of years. Two theories have been set forth, namely, the inorganic and the organic. The inorganic theories consider petroleum to have been produced from inorganic substances, while the organic theories state that is has resulted from the decomposition of animal or vegetable matter, or both. The organic

theories, while still subject to considerable speculation, are now generally accepted. The two general classes into which petroleum may be divided are those of the "paraffin-base" and the "asphaltic-base". The first class mentioned yields solid hydrocarbons of the paraffin series, while the other class is rich in asphalt and contains practically no solid paraffins. No sharp line of distinction can be drawn, as some oils contain both asphalt and paraffin. This may be said of the Oklahoma oils in general, although the percentage of asphalt is usually small. Chemically speaking, crude petroleum may be considered to consist essentially of a complex mixture of hydrocarbons of different boiling points often accompanied by sulphur, nitrogen and oxygen in small amounts.

Table No.1 is from a report "Comparative Analysis of Oklahoma Oils", presented to the Corporation Commission of Oklahoma by Dr. I. C. Allen, Petroleum Chemist, United States Bureau of Mines.

TABLE I.

	Okla. pools, Average of 139, excluding 2,3 and 4	Cushing pool, (Bartlesville sand only) composite of six samples	Boston pool Composite of five samples	Healdton pool Average of 20 samples
Spec. Gravity at 15°C.	.8544	.8190	.8330	.8666
Corresponding gravity, Be.	33.96	40.94	30.07	31.57
Calories per gr.	10870.	10975.	10927.	10785.
B.T.U. per lb.	19567.	19755.	19661.	19414.
Viscosity at 20°C. (Engler)	3.9	1.3	1.5	3.
Water per cent	0.	Trace	0.1	Trace
Sulphur per cent	0.23	0.22	0.15	0.70
Gasolene % by weight	8.1(59.6B)	25.8(58.5B*)	18.7(58.5B*)	6.0(57.7B)
By volume	9.4			7.0
Or by weight	13.8(56.3B)	32.9(55.4B*)	26.5(55.4B*)	11.2(54.4B)
By volume				
Kerosene % by weight	38.5(42.2B)	32.0(42.2B*)	32.8(42.2B*)	28.8(42.2B)
By volume	40.5			30.7
Or by weight	24.2(42.1B)	20.4(41.7B*)	22.1(41.7B*)	20.2(41.3B)
By volume				
Lubricants % by weight	26.1(29.1B)	23.2(29.5B)	29.5(29.5B)	29.7(29.9B)
By volume	25.3			29.4
Or by weight	34.7(30.0B)	27.7(31.7B)	32.4(31.7B)	33.1(33.4B)
By volume				
Residue % by weight	25.6	17.5	16.8	34.4
Loss % by weight	0.8	1.5	2.2	1.1
Total	100.0	100.0	100.0	100.0

*Estimated

It will be noted that the oil from the Cushing pool and Boston pool are comparatively high in percentage of gasolene.

Flash point determinations were conducted on samples of crude oil from the Cushing field and results as low as -18.5° C. (-1.3° F.) were obtained in the Abel-Pensky instrument. In general, Oklahoma oils have low flash points.

Tests of the explosive range of petroleum vapors have been conducted by numerous investigators, the results indicating that mixtures, of the vapor with air, containing 2.5 to 10 or 11 per cent vapor by volume are explosive. The most violent explosions are obtained with mixtures having 5 to 6 per cent of vapor present. From a study of the character of Oklahoma oils, we may consider the explosive range of the vapors to be close to the limits as stated above.

CONDITIONS IN OIL FIELDS AND ON TANK FARMS.

The main points to be considered in

an investigation of the general conditions in the oil fields and on the tank farms are: drilling methods, open fires, flow tanks, stock tanks and storage tanks.

Both steel and wooden drilling derricks are used in the Oklahoma fields. The majority of the rigs are made of wood, although structural steel derricks and those made of pipe joints are more or less common. The method of drilling usually employed is called the "dry hole" method of cable-tool drilling, as the hole is drilled with all water cased out. This method is similar to that employed in all eastern and northern oil fields. Only enough water is used to keep the drillings slushy. In this way the drill is allowed to perform its work properly and the bailer enabled to pick up the drillings and clean the hole. In Oklahoma a number of large gas wells have been drilled and in many cases difficulty has been encountered on account of the high pressure and large volume of gas. The waste of gas has been enormous, not only de-

creasing the natural resources but being a menace to life and property. It was to enable the operators to drill these wells without wasting gas that the"mud-laden fluid" method of drilling was introduced by the Bureau of Mines. The "mud-laden fluid" process, in brief, consists in drilling with the hole filled with a mixture of clay and water. The escape of gas from a well during drilling can be controlled and formations can be sealed so as to prevent further escape and waste. The advantages of the method have been demonstrated and there is no question as to its efficiency when properly applied.

In the Mid-Continental field, during the last year or two, blow-outs of gas have caused a number of deaths and serious accidents. In addition, the fire hazard has been great, owing to a large amount of highly inflammable gas being liberated.

In connecting up an oil well the usual method is to place a casing-head tee on the top of the inner string of casing, connect a flow-line to the side outlet, and extend the

line to a flow-tank without providing means of controlling the flow. In case it becomes necessary to shut off the well on account of fire or other reasons, considerable trouble is experienced.

Open flames are found in the oil fields in connection with fires under boilers, derrick lamps, derrick forges and the use of matches. With a gaseous condition of atmosphere there is considerable danger from open flames.

In the investigation of field conditions careful attention was paid to flow tanks and stock tanks. In general, the flow tanks observed in Oklahoma were of wood constructions. The sizes run from 100 bbl. (42 gallons per bbl.) to 1600 bbl. The sizes most in use are of 100 and 250-bbl. capacity. The roof is usually constructed of one-inch boards, loosely fitted together, and sometimes nailed to the top of the tank. Gas and oil vapors may be observed rising from the top of nearly every flow tank into which oil from a well is run. Some flow tanks have a wooden stack or several

wooden stacks, in which a series of baffles are fixed, on top of the flow tanks. These stacks are to allow the gas entrained in the oil to be released and pass out of the tank. The atmosphere near flow tanks usually consists of a flammable mixture of gas, oil vapors and air.

The oil passes from the flow tanks to the stock tanks. These are generally set up in batteries of two, three or four, and in general consist of 1600-bbl. wooden tanks. Smaller wooden tanks are often used and steel tanks are occasionally employed. Such flow tanks and stock tanks as represented typical conditions were selected for chemical and analytical examination of vapor contents.

The flow tanks selected were typical of prevailing conditions as follows:

(1) Oil flowing from well continuously.
(2) Oil pumped from well.

The stock tanks selected were typical of the following prevailing conditions:

(1) Tank receiving oil from flow tank.
(2) Tank discharging oil.
(3) Oil stored for various periods of time.

The methods of sampling and analysis of vapors are described in Appendix 1.

A sample of the vapors over the surface of the oil in a flow tank into which oil was flowing from the well showed an analysis 0.2% carbon dioxide, 11.9% air and 87.9% vapor. The roof on this particular tank was made of one-inch boards and nailed to the top of the tank. The oil flowed into the tank at the top from two six-inch pipes divided into four six-inch outlets. The holes in the roof for the flow pipes were packed with oakum. Gas was noticed leaking out around the edge of the roof. The tank was also provided with a wooden stack, about 24 inches square.

Another flow tank into which oil was flowing showed vapor analysis as follows: Carbon dioxide 2.0%, air 47.7% and vapor 50.3%. This tank had a very loose roof of boards, and the strong wind blowing at the time the sample was taken caused a higher

percentage of air to be present in the vapors, as shown by analysis.

Samples of vapor from a flow tank into which oil was being pumped showed an analysis to consist of the following percentages: Carbon dioxide 0.0, air 90.7 and vapor 9.3. This tank had a very loose wood roof, with an open hatch about 20 inches square in the center. The first flow tank mentioned was handling Cushing oil (Bartlesville sand), while the other two were being used in the Healdton fields.

Some of the data collected in the investigation of stock tanks, together with the analysis of vapor samples taken, are shown in Table 2.

TABLE II - STOCK TANKS.

TANK NUMBER	1	2	3	4	5
Oil Level	Falling	Rising	Rising	Stationary	Stationary
Type of Tank	Wood	Wood	Wood	Wood	Steel
Cap. in bbl.	1600	1600	250	250	250
(Opening (in tank	(Open hole in (top 30 in.sq	Open hole in top 30 in.sq	Open hatch 16 in.sq.	16" sq.hatch closed	2-6"dia.near edge;one open
Condition of roof	Not tight	Not tight	Not tight	Not tight	Fairly tight
Vapor Temp.	9.2° C.		4.4° C.	4.4° C.	3.5° C.
Air Temp.	9.5°	9.5°	2.4°	2.3°	2.7°
Vapor Sample	2	3	1	21	41
Percent CO2	0.0	0.0	0.0	0.0	0.0
Percent Air	99.3	94.1	97.0	99.4	98.9
Percent Vapor	0.7	5.9	3.0	0.6	1.1

Tanks No. 1 and 2 contained Cushing oil (Bartlesville sand).
Tanks No. 3, 4 and 5 contained oil from the Healdton field.

All of these samples were taken by means of a suction pump from over the surface of the oil at the centers of the tanks. In Tank No. 1 the percentage of vapor is low as the oil is being discharged from the tank and air is entering at the top to displace the oil withdrawn. The vapor samples from Tanks No. 2 and 3 show a higher percentage of vapor, due to the fact that the oil level was rising and air above the oil was being driven out of the top of the tank by the inflowing oil. The samples from Tanks No. 4 and 5 show a low percentage of vapor present. The oil in these tanks had been weathered about two weeks and the lighter constituents of the oil had been allowed to evaporate. The low temperature conditions as noted for Tanks No. 3, 4 and 5 might also help to account for the comparatively low percentage of vapor, as the oil was of lower specific gravity than that in Tanks No. 1 and 2. From our assumptions, the vapors in Tanks No. 2 and 3 may be considered explosive. No steam connections were observed on any of the flow or stock tanks mentioned above.

Many stock tanks are equipped with steam connections so that steam may be blown into a tank over the surface of the oil on the approach of a storm. Few are provided with permanent means of illumination. In some places the batteries of stock tanks are enclosed in a tank house, usually consisting of a shed constructed of boards loosely nailed together. Gas tanks are sometimes placed on the top of the flow tanks to aid in the separation of the gas from the oil.

The pipes between wells and flow tanks and flow tanks and stock tanks are generally grounded by a covering of earth at several places.

In the investigation of the conditions where oil is stored, tank farms in various portions of Oklahoma were visited and from a total of approximately three hundred steel tanks, twelve were selected as typical of general prevailing conditions. These conditions may be enumerated as follows:

(1) Receiving oil.
(2) Discharging oil.
(3) Recently filled with fresh oil.
(4) Various periods of storage in which oil has weathered.
(5) Oil previously weathered in open storage.
(6) Old oil recently topped with fresh oil.

These conditions are encountered normally in the storing and handling of oil, and embrace virtually the principal differences which are likely to affect the fire hazard.

From the selected tanks, and under varying conditions, representative samples of the vapor above the oil were collected.

The methods used in the collection and analysis of vapor samples are described in Appendix 1.

The results of analysis of the above mentioned samples, together with data collected on tank farms, are tabulated on the following page.

STORAGE TANKS

TANK TESTED Nº	2	14	14	109	117	136	57	19	101	524	525	47	48
Size of Tank (Bbls)	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	55,000	35,000	25,000
No. of Tanks on Farm	14	14	14	32	32	32	72	72	2	5	5	4	4
Type	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Roof	Wood covered with galvanized iron nailed on.			Wood, Paper & Tarred			Wood with Galv. Iron lapped.		Wood and Galv. Iron	Wood & Paper		Wood with Iron Painted	
Tightness	Apparently tight lapped over edges.			Apparently tight			Fairly good.		Fair	Fairly tight		not tight	
Openings	1 Winch box, 5' from edge			2 winch boxes			1 winch box		1 winch	One gage hatch.		1 winch 1 hatch.	1 winch.
Size	23½" x 25½" for swing pipe			24" x 26" each.			24" x 26"		26" x 26"	5" diam.		24" x 26"	24" x 26"
Covers	Flat iron plate, not tight			Iron plates with asbestos gaskets and screw clamps			Flat Iron plate		Iron plate	no covers		Wood cover Iron plate	Iron plate
Vent. Size	4-8" diam. with gal. slip covers			4-8" diam. screw caps.			4-8" diam.		4-10" diam.	1-5" diam.		4-7"	4-7"
Location	3'-6" from edge of tank			2'-0" from edge			3'-6" from edge		7'-0" from edge	7'-0" from edge		5'0" from edge	6'0" from edge
Connections, oil.	4" line	4"	4"	6"	6"	6"	6"	6"	4"	4" & 3" in	6" out	4" & 6" in	6" out
Steam No. Size	2-2"	2-2"	2-2"	2-2" plugged at goose necks			2-2"	2-2"	2-2"	2-2"	2-2"	2-2"	2-2"
Embankment, diam.	265'	265'	265'				275'	275'	260'				
Height	6'	6'	6'				6'	6'	5'	6'-6"	6'-6"	5'	5'
Ground Connections	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried	Buried
Gage	29'-1$\frac{5}{8}$"	10'-8½"	10'-8½"	29'-8"	29'-1$\frac{5}{8}$"	29'-8"	29'-8"	30'-0"	29'-2"	5'-1½"	7'-3$\frac{5}{8}$"	24'-7$\frac{7}{8}$"	23'-5$\frac{3}{8}$"
Original Gage	29'-2"	Filling	Filling	29'-8"	29'-8"	29'-8"		30'-0"	29'-5¾"	Work Tank		Work Tank.	
Temperature	15.5°C.	12.7°C.	12.7°C.	15.5°C.	16.6°C.	15.5°C.			14.4°C.	10.6°C.		11.6°C.	11.1°C.
Original Temperature					23.3°C.								
Gravity Bé	37°	40°+	40°+	40.3°	42.3°	42°			37°			32.5°	38.4°
Date Filled	10-27-14	Filling	Filling	6-26-14	9-28-14	11-30-14	Several months ago	11-30-14	6-5-14	Draining	Filling	Filling	Filling
Vapor Sample No.	1 and 4	1 and 2	3 and 4	3 and 4	3 and 4	1 and 3	1 and 4	1 and 3	2 and 3	1 P and 1 K	1 P and 1 K	1 K and 1 P	1 K and 3 P
How Taken	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump	Pump and Kerosene	Pump and Kerosene	Pump and Kerosene	
Height above Oil	6"	14'-6"	14'-6"	6"	6"	6"	6"	2" 6"	6"	20'-0" 24'-0"	18'-0" 22'-0"	5'-0" 2'-0"	7'-0" 2'-0"
Distance from Edge	3'-6"	3'-6"	3'-6"	2'-0"	2'-0"	2'-0"	3'-6"	3'-6"	7'-0"	7'-0" 7'-0"	7'-0" 7'-0"	15'-0" 5'-0"	6'-0" 6'-0"
Air Temperature	12.5°C	12.5°C	12.5°C	8.5°C	8.5°C	8.5°C	9.5°C	9.5°C	10.5°C	4.6°C	4.6°C	4.0°C	3.8°C
Vapor Temperature	14°C	12.7°C	12.9°C	11.5°C	11°C	11°C	11.5°C	11.0°C	12°C	6.5°C	6.5°C	5.5°C	6.3°C
Wind	Strong North Wind			Strong North Wind			Strong North Wind		Strong North Wind	Strong North Wind		Strong North Wind	
Per Cent Air present	96.5 92.7	93.6 91.7	94.6 93.2	97.5 98.4	98.9 98.4	94.6 93.6	98.4 93.6	97.0 99.8	99.8 Lost	99.4 99.8	98.4 98.9	96.0 96.5	97.5 97.5
Per Cent Vapor present	3.5 7.3	6.4 8.3	5.4 6.8	2.5 1.6	1.1 1.6	5.4 6.4	1.6 6.4	3.0 0.2	0.2 Lost	0.6 0.2	1.6 1.1	4.0 3.5	2.5 2.5
Elevation of Tank	On Level with surrounding Ground						Flat Ground		Low	Low Ground		Low Ground	
Date	12-1-14	12-1-14	12-1-14	12-2-14	12-2-14	12-2-14	12-1-14	12-1-14	12-3-14	12-9-14	12-9-14	12-9-14	12-9-14
Special				Topped-11-29-14	not Topped					Glenn Pool Oil		Osage Oil	

The tank farm on which Tanks No. 2 and 14 were located had secondary fire walls in addition to the embankment around each tank. These additional walls were about 7 ft. in height and consisted of earthen cross wall between each row of tanks. The tanks are spaced 500 - 600 ft. from center to center, the shortest distance being 527 ft. and the longest 600 ft. Goose necks on Tank No. 14 were open at the time the samples of vapor were taken. The vents at which samples No. 1 and No. 3 were taken were 3½ ft. from the open goose necks.

Tanks No. 109, 117 and 136 were located on the same farm. The goose necks on all the tanks on this farm were plugged. Four 25-H.P. boilers are to be erected and permanently connected with all tanks. The steam lines will be covered with earth at intervals for grounding. A cannon to fire a three-inch ball has been ordered for this farm. Secondary fire walls are to be erected in the near future. Tanks on the farm where No. 57 and 19 are lo-

cated have steam connections, from goose necks, buried, run outside of embankment and flanged. Mounted boilers are ready to be moved to tank and connected.

All of the steel tanks from which vapor samples were collected, except those otherwise mentioned, contained Cushing crude oil.

All vents on Tank No. 19 were open when vapor samples were taken. Two vents on No. 57, opposite to where samples of vapor were collected, were open. Seepage oil from No. 57 was being pumped back into the tank at the time the tank was visited.

Tank No. 101 was filled with oil that had been in open storage for about one month previous to being pumped into steel storage. The goose necks on Tank No. 101 were permanently connected with two boilers.

Tanks No. 524 and 525 are work tanks located on the same farm and near a pump station. No vents were provided on these tanks. The only openings in the roof are those where the flow pipes enter and one

gage hatch 5 inches in diameter. No covers are used on these openings. The filling pipes extend a few inches below the surface of the roof. A winch is mounted on the outside of the bottom ring on each tank and a $\frac{7}{8}$-inch wire line passes over a pulley and through hole in roof to swing pipe. Four 25-H.P. boilers are connected by one 2-inch line to the tanks. Each tank has two 2-inch steam connections to the goose necks. Extra earthen cross walls about 6 feet high were thrown up between the embankments.

Tanks No. 47 and 48 are both work tanks located near a pumping station in which twelve boilers are set up. Each tank has two 2-inch steam lines, but no goose necks. The roof on Tank No. 47 was in poor condition and was probably not rain-proof. One electric reflector light was located on a post, just outside of the embankment, around each tank.

Tanks No. 14, 525, 47 and 48 represent condition (1).

Tank No. 524 represents condition (2).

Tanks No. 136 and 19 represent condition (3).

Tanks No. 117 and 57 represent condition (4).

Tank No. 101 represents condition (5).

Tanks No. 2 and 109 represent condition (6).

No carbon dioxide was found to be present in any of the vapor samples collected from the storage tanks above.

The system used in numbering vapor samples from different parts of the tanks was as follows: No. 1, north side; No. 2, east side; No. 3, south side; and No. 4, west side.

Samples of the vapors above the oil in steel storage tanks, taken at the vents, cannot be considered as truly representative of the vapor contents, although comparative results may be obtained in this way.

The analyses of samples from tanks representing condition (1) show the percentage

of vapor present to vary from 8.3 to 1.1. The samples taken from Tank No. 14 show a variation from 8.3% to 5.4% of vapor present. Samples No. 1 and No. 3 show higher percentage of air than No. 2 and 4, on account of the fact that the vents on the north and south were near open goose necks and a strong wind was blowing from the north. The air temperature and temperature of the oil was in the neighborhood of 15.5° C. for several days before the tank was visited and the flowing fresh oil gave off vapors readily.

The percentage of vapor in samples collected from Tank No. 525 is low, as the level of the oil in the tank was about 18 and 22 feet below the intake for the sample bottle, and the air and vapor temperature was comparatively low. The conditions in Tanks No. 47 and 48 were similar to those in Tank No. 525, except that the oil level was higher and the samples were collected at distances of two, five and seven feet above the oil, instead of eighteen and twenty-two. In the last three tanks mentioned fresh oil from the field was being pumped.

Tank No. 524, representing condition (2), that of discharging oil, shows a very low percentage of vapor in the samples collected above the oil. The fact that air was being drawn in at the top of the tank to replace the oil that was being discharged is an explanation of the high percentage of air present in the vapor mixture. As may be noted from the tabulated record, the temperature of the incoming air was more than 5.5°C. lower than that of the oil. The samples having been collected twenty and twenty-four feet above the surface of the oil in the tank, might give added explanation of the low vapor percentage.

The third condition listed, represented by Tanks No. 136 and 19, shows data on tanks recently filled with fresh oil. The percentage of vapor present in samples from above the oil in Tank No. 136 is 5.4 and 6.4. The higher percentage of air in the sample taken at the north vent is probably due to the fact that strong wind was blowing from the north. Sample No. 1 from Tank No. 19 shows 3.0% of vapor,

while No. 3, from the same tank, shows only .2%. It should be remembered that there were no covers on any of the vents on Tank No. 19. The higher percentage of vapors in No. 1 might also be explained by the fact that this sample was taken two inches from the surface of the oil, while No. 3 was taken six inches above the oil.

Under condition (4), Tank No. 117 presents a tank of oil that was in storage over two months without having been topped. The original specific gravity of the oil was 43°Be. at 74°F., while at the time of test the gravity reading was 42.3°Be. at 62°F. During the period of storage, the level in the tank had decreased 6-3/8 in., showing a loss by evaporation and leakage of approximately 1000 bbl. The percentage of vapor present in the samples collected was comparatively low. One sample from Tank No. 57 showed a percentage of vapor close to that recorded for Tank No. 117, but the other sample showed a much higher amount. This sample No. 4 was taken at a vent near an inlet pipe, from which oil was flowing into the tank. This, in

all probability caused more vapor to be present in the mixture.

One tank was visited that contained oil that had been weathered in open storage previous to the time it was pumped into steel storage. Tank No. 101 shows this condition. The analysis showed the presence of 99.8% air and 0.2% vapor in the sample collected from the above oil in this particular tank. The loss of oil by evaporation and leakage during the six months that it had been in steel storage was only about 400 bbl. The lighter constituents of the oil were lost by evaporation during the one month that the oil remained in the earthen tank. The absence of the lighter hydrocarbons from the oil in the steel tank accounts for the lower percentage of vapor present in the sample collected.

Tanks No. 2 and 109 represent condition (6), that of a tank of old oil recently topped with fresh oil. Tank No. 2 was topped about one month previous to the time at which samples were taken and the vents had been closed

most of the time from then on, while No. 109 was topped only two or three days previous to the time of sampling. The presence of a higher vapor percentage in samples from Tank No. 2 is probably due to the fact that the oil in this tank had not been allowed to weather as long as the oil in Tank No. 109 before being topped with fresh oil. The strong north wind was probably responsible for the higher percentage of air in sample No. 1 from Tank No. 2 than in sample No. 4 from the same tank.

Based on the assumptions made relative to the explosive range of vapor-air mixtures, the analyses show that Tanks No. 2, 14, 136, 47 and 48 contained explosive mixtures in all places tested. Samples from one part of Tanks No. 109, 57 and 19 are explosive, while other samples from different parts of the same tank contain too small an amount of vapor to render them explosive. The vapors from tanks No. 117, 101, 524 and 525 may be considered as non-explosive.

No investigation was made of wood

storage tanks other than those used as stock tanks.

The investigation of oil in earthen reservoirs was not taken up directly in the field. It may be easily perceived that the lighter constituents of the oil will soon pass from it into the air when no roof is provided for the tank. The roofs on any covered earthen tanks are generally of loose wood construction and evaporation takes place, but not quite as readily as in the case of open storage. The vapors over an earthen storage tank would, in all probability, be explosive only when the oil is fresh.

CAUSES OF OIL FIRES.

Oil fires may be attributed to many different causes falling within two general classes, viz: ignition by electrical discharge and ignition by communicated flames. The majority of the oil fires in the states of Oklahoma and Texas have been caused by lightning and fall under the first general class.

The boiling over of burning oil has often communicated flames from one tank to its surroundings and caused additional losses.

Lightning has caused fires by striking derricks, gas wells, oil wells from which considererable quantities of gas were allowed to escape, flow tanks, stock tanks, gathering lines, storage tanks, pipe lines, loading racks, etc. In an oil field, lightning does not always strike single objects. Eye-witnesses in the Cushing field state that a single flash of lightning, on August 27, 1914, caused a dazzling sheet of flame more than three-quarters of a mile in length and simultaneously ignited three 55,000-bbl. steel tanks, two 1600-bbl. wood stock tanks, one 800-bbl. flow tank, one 500-bbl. flow tank and one gas well, covering a range of one mile in length and one-fourth of a mile in width. A number of tanks and wells within this zone were not affected, although some of these were later destroyed by another flash of lightning. The large extend of the first fire may be considered as due to the fact that the

lightning flashed into a highly flammable atmosphere, over the field, composed of air and gas.

Open fires have been responsible for some quite extensive conflagrations and a number of smaller oil fires. Ignition has been caused by fires under boilers or in derrick forges, by unprotected lamps, burning matches and smoking. Defective electrical installation and unprotected electric light globes may also cause oil fires and have been known to do so. Friction may be the cause for a number of smaller fires. Under the subject of friction many sources may be listed, such as: Pulleys in crown block on derrick, pulleys in casing block, slipping of bull rope, slipping of drilling line through the clamps, bull wheel bearings and brake, calf wheel bearings, band wheel bearings in engine house, wire rope working off calf wheel and striking some metallic part, wire line slipping on itself while being wound on bull wheel, untwisting of line when released in clamps, nailes in boots on metallic parts

on derrick floor, sparks from one source or another coming in contact with oily rope fiber or other oil soaked material, use of hammer and chisel near head of well, pebbles striking each other or rubbing against the casing as they are expelled with the gas or oil, lowering or raising tools or bailer in casing, drilling line on casing and gas or oil in casing causing accumulation of electrostatic charge.

Numerous miscellaneous causes may be mentioned, among which are grass fires, brush fires, spontaneous heating of oily clothes and ignition of waste oil in the field or near storage tanks. Oil fires have also been caused by the ignition of waste oil or gas from leaks in pipe lines. Lighted automobile head lights have caused the explosion of gas in an oil field, resulting in the loss of life and property.

PRESENT METHODS OF FIRE PROTECTION.

The precautions commonly taken for

protection against loss by fire are as follows:

(1) Installation of steam jet connection at the head of a drilling well.

(2) Protection of the head of a flowing well by earth covering to a depth of three or four feet.

(3) Permanently grounding all flow lines or other pipe lines before making tank connections.

(4) Building a retaining wall or embankment around each tank or battery of tanks.

(5) Steam connections to all tanks and maintainance of steam pressure in boilers so that live steam may be turned into tanks on the approach of a storm.

In the protection of a drilling well a connection is often made with the steam line near the engine and a 2-inch pipe is run along the walk and into the derrick. This pipe terminates at the head of the well in a section with a flattened end, which forms a horizontal fan-shaped jet when the steam is turned on. This steam jet is not so much a means of preventing fire as a means for "snuffing-out" flames before greater damage is done. A stop cock is placed in the steam line near the

engine and the line is sometimes furnished with a swing joint at the base of the "headache post" so that the nozzle end may be easily moved out of the way so as not to be a hindrance in the drilling operations.

The covering of the head of a flowing well with earth to the depth of three or four feet is a method used to some extent. This probably serves to protect the well from ignition by lightning, but affords no protection to the well should the flow tank be ignited.

The practice of grounding all flow lines and other pipe lines before making connections to tanks is generally observed in the oil fields and on the tank farms. The usual method employed for pipe lines laid on top of the ground is to bury them for a short distance near each tank or well to which they are connected. Unless pipe lines are properly grounded, there is a danager of lightning causing the entire pipe line to become heavily charged. This might result in serious fires at all tanks and wells to which the line connects.

The embankments, built up of earth, around tanks are usually high enough to retain the contents of the tank in a quiet state, but when the oil is heated to such an extend that boiling occurs, and particularly if the earth is wet or water covered, the boiling of the oil causes it to overflow the embankment. In such a case additional embankments are usually thrown up to prevent the spread of the flames. Cannons are sometimes provided on tank farms, in order to be able to shoot a solid projectile through the walls of the tank. In this way the oil can be permitted to run out over the surface of the ground where it will burn harmlessly within its prescribed bounds.

It is customary to turn steam into all flow tanks, and generally into stock tanks, upon the approach of a storm. Most of the steel storage tanks are provided with steam connections at the goose necks, but some tanks have no provisions made for the use of steam over the surface of the oil contents. The steam, when properly applied, causes the liberated gas and

and oil vapors to be blanketed and rendered incombustible. The steam lines in many instances are laid on the surface of the ground, uncovered, and the heavy rains that usually accompany an electrical storm in Oklahoma serve to cool the pipe and cause condensation. It is doubtful whether a sufficient volume of steam could be delivered through such a line to be effective at a tank any distance away. The apparent failure, in some cases, of steam to prevent the loss of tanks by fire cannot be considered as a proof that it is inadequate; the methods of application were probably at fault.

SUGGESTED PRECAUTIONS.

The precautions usually taken have undoubtedly, in many instances, prevented fires or served to reduce the amount of loss by fire. It is also true that there have been instances when the best methods of protection yet applied have failed in their purpose. As previously stated, it is the object of this report to present precautionary methods for the reduction and prevention of further fire losses. Suggestions will be taken up in logical order, from the drilling of the well to the storage of the oil.

Methods of drilling in which the escape and waste of gas may be eliminated should be employed rather than the "dry-hole" method. Good suggestions are offered in the summary of Technical Paper 68 of the Bureau of Mines, by A. G. Heggem and J. A. Pollard, entitled "Drilling Wells by the Mud-Laden Fluid Method":

"The demonstrations by the Bureau

of Mines show that the waste of natural gas in drilling and casing oil or gas wells is entirely unnecessary and may be prevented by suitable precautions. These precautions may be outlined as follows:

(1) Seal each gas-bearing stratum as it is encountered, by drilling with the hole full of mud-laden fluid.

(2) Set each string of casing with a secure and water-tight seat, using a long shoe or packer to assure tightness.

(3) When casing through a gas-bearing stratum, keep the space between the casing and wall full of muddy fluid.

(4) Place a gate valve on top of the inner string of casing before drilling into any gas-bearing stratum.

(5) The string of casing through which gas is taken should be seated on top of the gas sand and the gas should be prevented from coming in contact with the wall of the hole above the sand.

This precaution should be observed when gas is taken through a braden-head at an oil well, as well as when well is drilled for gas alone."

A good way of protecting a "drilling well" from damage by fire is to carry a suitable quick closing valve on the top of the last string of casing seated in the well. Such valves should be constructed so as to permit drilling through them without hindrance and to be closed without removing the tools from the hole. On the approach of a storm the valve may be closed and the danger of the well being ignited eliminated.

A suitable extinguisher should be located on the derrick floor, to be readily accessible in case of small fires about the rig.

The various sources of friction, as noted in the previous section of this report, should be investigated and properly handled.

The use of open flames in an oil field should be eliminated as far as possible.

In the protection of a flowing well by covering the head of the well with earth, a valve should be placed on the head with an operating stem extending through the covering. By this means, should the oil become ignited at the end of the flow line, the flow may be shut off

until the fire has been extinguished.

Flow tank roofs should be so constructed as to be tight. The cracks and openings should be caulked and tightly closed. An open stack should be built in the center of the deck to permit the liberated gas to escape. This stack should be so constructed that when steam is turned into the tank the escaping gas will be entirely blanketed by the steam and combustion prevented. On the approach of a storm steam should be turned into all flow tanks. It might be well to build the stack on the tank in such a way that, in case of gas burning at the top it could be pulled over and the flame thus cut off. This has been done successfully, but it is an open question as to whether it would work satisfactorily in all cases.

The stock tanks should be covered with decking made as tight as is practical. As in the case of flow tanks, steam lines should be provided and on the approach of a storm steam should be turned into all stock tanks.

Steam lines for all tanks should be of

large size and enclosed in tight wooden boxes or otherwise insulated to prevent condensation. Suitable ground connection should be made at each tank.

All pipe lines should be either underground or buried for a short distance near each tank or well to which they connect.

Drainage pipe connections of large size should be made to each tank, whereby a portion of the contents may be withdrawn by means of suction pumps and delivered to other tanks at a safe distance from the fire. Strainers or lage capacity, and so arranged as to be readily cleaned without interrupting the flow of oil, should invariably be installed in such suction lines, as otherwise the pump would be rendered inoperative by the quantities of charcoal or other material that would find its way into the suction line with the oil.

The most effective means know of reducing the fire hazard of oil in steel storage would be the equipment of all steel tanks with gas-tight steel roofs, properly vented, so as to

eliminate any possibility of back-firing. All steel tanks and pipe lines connected to them should be thoroughly grounded electrically. The wood roofs at present in use on steel tanks may be greatly improved by covering roof with a metallic sheathing, making good gas-tight electrical connection with the shell of the tank, thoroughly grounding the tank electrically, and making roof gas-tight. The electrical connection between the metallic covering, over the wood, and the shell of the tank may be made by bringing the sheathing over and under the angle iron at the top of the shell. This joint should be made gas-tight by means of caulking or a suitable material used as a gasket. The top angle should be tightly caulked to the shell, using small additional rivets where necessary.

The use of riveted and caulked steel roofs on steel rafters with the posts, plates, etc., of steel, would result in giving tanks of the best construction obtainable. The estimated cost for such a roof would be, for a 55,000-bbl. tank, about $5,000.00, while the cost of the

wooden roofs at present in use is in the neighborhood of $3,000.00. A very conservative estimate of three percent saving yearly, due to decreased evaporation losses with gas-tight roofs, should be considered. Figuring that the average amount in a 55,000-bbl. tank is 50,000 bbl., the yearly saving would be 1500 bbl. of gasoline. As this gasolene is worth at least $2.50 per bbl., the yearly saving due to the gas-tight roof would be about $3,750.00. On this basis, the difference of $2,000.00 in cost between the steel roof and the wood roof would usually be saved in a little over six months and in any case in less than one year. A new wooden roof could be replaced by a steel gas-tight roof and the whole expense could be met by the savings due to decrease in evaporation losses in two to three years.

As a thoroughly grounded gas-tight tank of metal, or one sheathed with metal, is safe from damage by lightning, and will also reduce evaporation losses to a very marked extent, the additional cost of the steel roof will

be saved in a comparatively short time.

The use of explosion hatches is strongly advocated by some tank builders and tank owners; but with a gas-tight steel roof and proper vents, in a territory where fires and explosions from causes other than lightning are not feared, no explosion hatches would be needed. As an additional safe-guard, they might be used. If used at all, the explosion hatches should be of very light constructions.

Tanks equipped with gas-tight roofs should be provided with suitable vents to take care of the rise and fall of the level in the tank due to in-flow or discharge of oil. These vents must also prevent the ignition of the gas in the tank through the vent. The use of a glycerine or an oil sealed vent should be preferred, as it maintains a slight pressure in the tank. The use of glycerine in the seal is recommended, as glycerine does not evaporate readily and is not materially affected by ordinary temperature changes. The use of a vent that maintains a slight pressure in the tank

will aid in reducing evaporation.

The gage hatches in the roof should be made tight or have hinged covers which, by their own weight, would maintain a gas-tight joint. These hatches should be closed, except when gages are being taken. The location of these hatches is a matter of choice, but placing of one near the stairs would be very convenient for ordinary gaging.

The winch-box, or boxes, should be gas-tight to carry out the plan of making the roof gas-tight.

As the value of the gas-tight roof depends upon its condition, careful inspection should be made frequently of the roofs, vents, gage hatches and explosion boxes, if any are used.

Another idea in connection with the use of gas-tight steel roofs is to be tried out in the near future in Oklahoma. The tank is to be so constructed that a small pressure, say three ounces, will be maintained in the tank at all times. When this pressure increases, due to

expansion of the vapor above the oil, it will be relieved automatically and kept at the correct amount. If contraction of the vapor occurs, natural gas will be introduced over the surface of the oil to maintain the proper pressure. With such an arrangement, the evaporation will be reduced to a minimum and the mixture over the oil will be kept too rich in vapor to explode. A pressure regulating device could be placed on the tank and no difficulty would be encountered in maintaining the desired pressure in the oil tank.

Another economical system would contemplate the use of gas-tight tanks for oil, with a suction pipe connection to the space above the oil, whereby the gas which arises from the oil may be withdrawn from the tank. This gas could then be delivered to a compressing tank for extraction of gasolene, utilized commercially as a fuel, or carried to a safe distance from the tank before liberation.

As an added precaution, all storage tanks might well be provided with suitable steam

connections to be used in case of emergency. Proper oil connections would be of advantage in drawing off oil from a tank in case of fire. Pump stations and tank farms should be so equipped as to be able to handle large quantities of oil in transferring from one tank to another in case of an emergency.

The question as to whether an empty tank should be set aside on each tank farm, to be used in case of fire, is subject to much discussion. The expense of erecting a spare tank seems to be the main objection offered to this course. It would be advisable, if possible, to keep some space available on each tank farm.

The practice of storing oil in the producing field should be discouraged, as it has the disadvantage of concentrating the fire hazard and it would seem that, as far as possible, storage tanks should be erected in a district remote from the producing field and beyond the possible fire zone of the field.

The placing of additional cross walls

on a tank farm would be of marked advantage, in case of a burning tank boiling over. Protection would thus be afforded to adjoining property. The distance between tanks on a farm should also be considered. Cases have been recorded in which burning oil has been thrown approximately 500 feet from one tank to another, causing further damage. It is suggested that tanks be placed as far apart as possible, to avoid danger from this source.

The use of a tenacious foam solution as a means of extinguishing oil fires has been brought to the attention of the oil producers by experiments recently carried out in the East by one of the large oil companies. The process consists essentially in mixing two chemical solutions, to produce a thick tenacious foam, containing bubbles of carbon dioxide, and in spreading this foam over the surface of the burning oil. There are two methods of application of the foam: 1st, distribution from a central generating plant through pipe lines; 2nd, automatic distribution from generators on

each individual tank. The first method would seem to be more applicable where there are many tanks in a group and plenty of steam available for pumping. The second method would be more advantageous for isolated tanks and on large tank farms where many tanks would be located at a distance from the steam plant. The distribution of foam from generators on each individual tank has the advantage that the generators are installed so that they will operate automatically. Frequent inspection would probably be necessary to insure proper action of the generators at the time needed.

The foam method of extinguishing oil fires seems to have merit, but its use to date does not place it in such a position that any recommendations may be fairly made as to its practicability for control of fires in large tanks, such as the 55,000-bbl. size. The use of the foam blanket should be very carefully studied under favorable and unfavorable conditions before any recommendation can be made.

Lightning rods have been applied to

storage tanks without marked benefit; in fact, it has at times seemed that the tanks carrying lightning rods were the most likely to be destroyed.

Attention was paid to the subject of the accumulation of static charges due to friction of oil or gas in pipe lines, but no satisfactory conclusion could be reached.

Pipe lines along highways should be protected from injury due to heavy vehicles passing over them. In looking up the historical section of this report, a case was noted in which one life was lost due to such an occurrence.

The precautionary suggestions offered above are based upon the record of past fires and the conditions observed in the Oklahoma oil fields in 1914, during the months of November and December. Most of the data on flow, stock and storage tanks was collected during December. From the tabulated history of oil tank fires, it will be noted that the condition of oil storage during the months of December and January seems to be of immunity from fire hazard.

APPENDIX I

METHODS OF SAMPLING AND ANALYSIS OF VAPOR.

The majority of the vapor samples were secured by means of a suction-pump, having a displacement approximately equal to the capacity of the sample bottle. Patent-stopper soda bottles, holding half a liter (about one pint), were used for collecting the samples. The free end of the intake tube on the pump was placed in the vapor to be sampled and the free end of the outlet tube at the bottom of the inverted sample bottle. To insure a thorough displacement of the original air in the bottle by vapor, fifty-five strokes of the pump were used in taking a sample, i.e., approximately fifty times the volume of the sample was passed through the bottle and rejected before the sample was accepted as representative. While the gas was still being pumped through the tube, the tube was slowly withdrawn. The stopper was placed in the bottle and made secure as soon as the

tube was withdrawn; then the bottle was turned up and the stopper sealed with melted paraffin.

In the places where it was impractical to use the pump, the sample bottle was filled with kerosene or with dead oil, from which all free gas had been liberated, and allowed to empty into the tank, thus transferring a portion of the vapor contained in the tank into the bottle. Independent tests were made on the oil used in taking samples of vapor in this manner, to determine whether any correction was necessary for vapors which may be entrained in the oil. Under similar conditions, the samples taken by oil displacement gave identical results with those obtained by the pump method.

The portable outfit used for the analysis of the vapor samples is a modified Orsat apparatus and consists essentially of a burette and two pipettes. The burette has a capacity of 100 cubic centimeters and is graduated to two-tenths of one cubic centimeter. The first pipette into which the gas is passed contains potassium hydroxide solution for the

removal of oxygen. The pipettes contain glass tubes, to increase the absorbent surface of the reagents.

Before an analysis is begun, the solutions in the pipettes are brought exactly to the marks indicated on the capillary tubes above the pipettes, by suitable manipulation of a level bottle. The sample is transferred to the burette by water displacement and about one minute is allowed before the measurement is taken, in order to guard against a small error that would result if this interval of time was not allowed for drainage of water down the sides of the burette.

After measurement, the sample is passed back and forth three or four times between the burette and the potassium hydroxide pipette, and any carbon dioxide present is removed. Finally, the solution in the pipette is brought exactly to the mark on the capillary stem and the sample is measured, one minute's time being allowed for drainage. The loss in volume indicates the amount of carbon dioxide

originally present in the sample. The sample is next passed into the pipette containing the alkaline pyrogallate solution. Five or six passages of the gas from the burette to this pipette are necessary, as an alkaline pyrogallate solution does not remove oxygen from a gas mixture as rapidly as a potassium hydroxide solution removes carbon dioxide from a mixture. As before, the solution in the pipette is brought exactly to the mark on the capillary stem and the sample is measured, one minute's time for drainage being allowed. The contraction in volume indicates the amount of oxygen absorbed.

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